RHIC/AGS
Ann. Users' meeting
May.11,2004.
K. NAKAZAWA
Gifu / Japan

Nuclear Physics with double strangeness (S=-2)

KEK-E373 => AGS-E964 ……> J-PARC

Λ Observation of a $^{6}_{\Lambda\Lambda}$He (KEK-E373)

Success of Emulsion detector with micro-meter accuracy

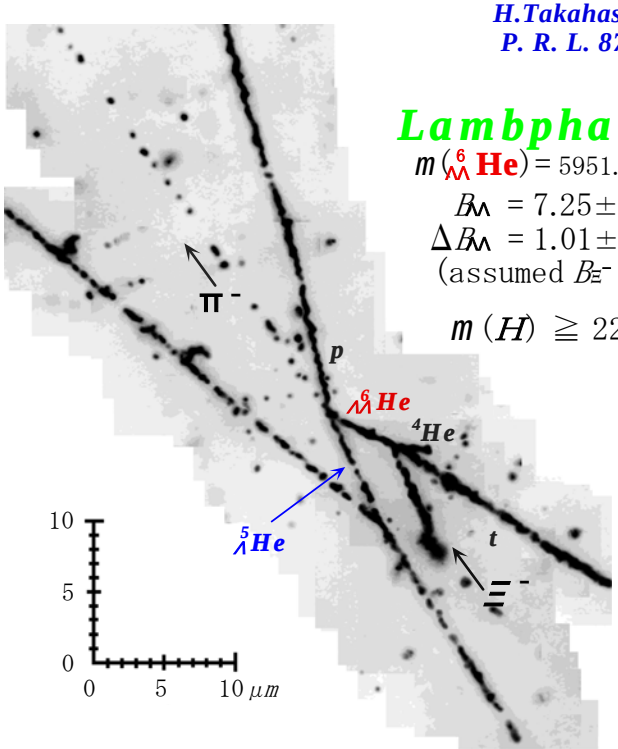
NAGARA event

$^{6}_{\Lambda\Lambda}$He double-hypernucleus

Unique interpretation!!

$$\Xi^- + {}^{12}C \rightarrow {}^{6}_{\Lambda\Lambda}He + {}^{4}He + t$$
$$^{6}_{\Lambda\Lambda}He \rightarrow {}^{5}_{\Lambda}He + p + \pi^-$$

H.Takahashi et al.,
P. R. L. 87, 212502(2001)



Lambpha

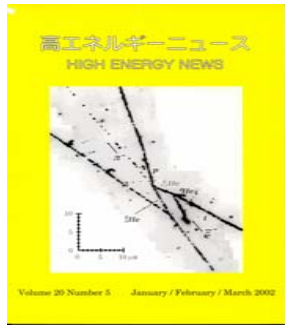
$m(^{6}_{\Lambda\Lambda}He) = 5951.82 \pm 0.54$ MeV

$B_{\Lambda\Lambda} = 7.25 \pm 0.19^{+0.18}_{-0.11}$ MeV

$\Delta B_{\Lambda\Lambda} = 1.01 \pm 0.20^{+0.18}_{-0.11}$ MeV

(assumed $B_{\Xi^-} = 0.13$ MeV)

$m(H) \geqq 2223.7$ MeV/c^2
(90% C.L.)



High Energy News
Vol.20 No.5 (2002)
KEK

Demachi-yanagi event

* **two body** case at point A

$\Xi^- + {}^{12}C \rightarrow {}^{10}_{\Lambda\Lambda}Be + t$ or ${}^{10}_{\Lambda\Lambda}Be^{*} + t$

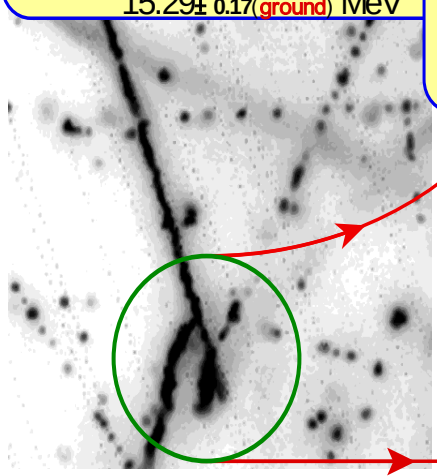
$\Delta B_{\Lambda\Lambda}$: -1.14± 0.19 or +1.86± 0.19 MeV

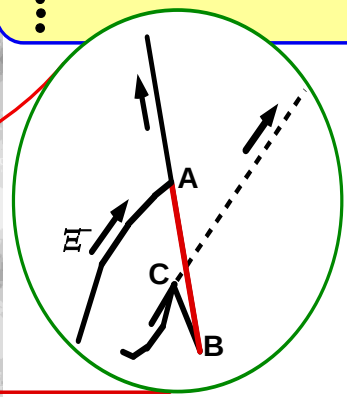
$B_{\Lambda\Lambda}$: 12.29± 0.17(excited) MeV
15.29± 0.17(ground) MeV

* **three body** case at point A

1) $\Xi^- + {}^{14}N \rightarrow {}^{13}_{\Lambda\Lambda}B + p + n$

$\Delta B_{\Lambda\Lambda}$: $+1.47^{+2.4}_{-0.7}$ MeV





http://www.phys.ed.gifu-u.ac.jp/Topics/NAGARA-e.htm

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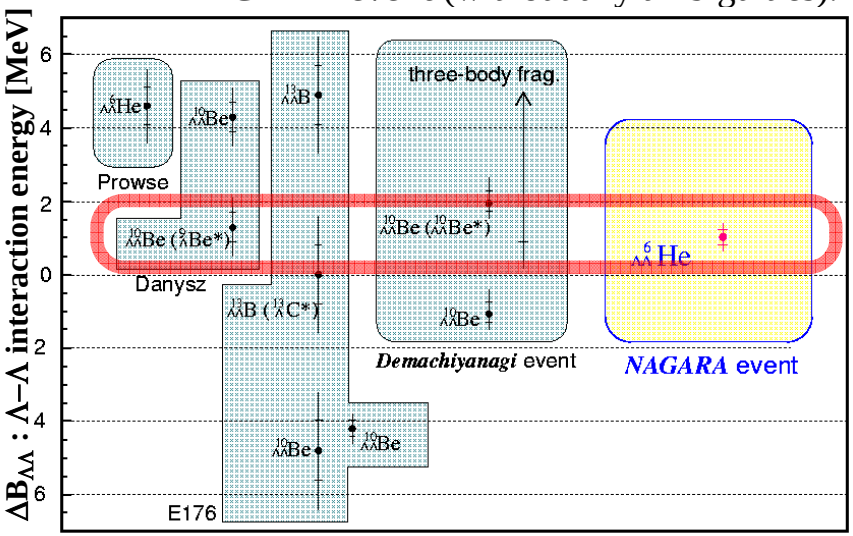
From KEK-E373 output to AGS-E964

KEK-E373 (Preliminary results)

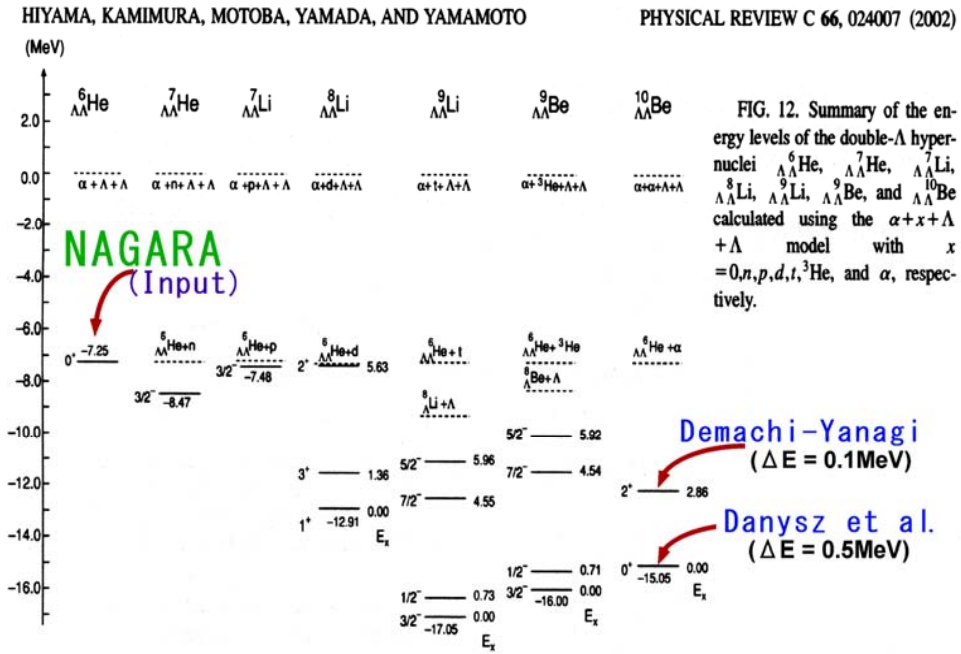
*) **~10^3 Ξ^-** stopping events in nuclear emulsion.

*) Observation of several double-Λ hypernuclei
=> **NAGARA event** (without any ambiguities).



ΛΛ interaction is attractive but weak

Theoretical calculation for light double hypernuclei



AGS-E964 (statistics x 10)

*) **~10^4 Ξ^- stopping events** in nuclear emulsion.

*) **~10** double-Λ hypernuclei (**without any ambiguities**).
=> making a **nuclear chart with S=-2**.
A-dependence of $\Delta B_{\Lambda\Lambda}$ in several nuclides.

*) **X-ray measurement** from Ξ^--atom, for the first time.
=> information of Ξ-N interaction.

*) **funded $2.5M** by JPN. Gov., already. (2003~2007)

Nuclear Chart with Strangeness

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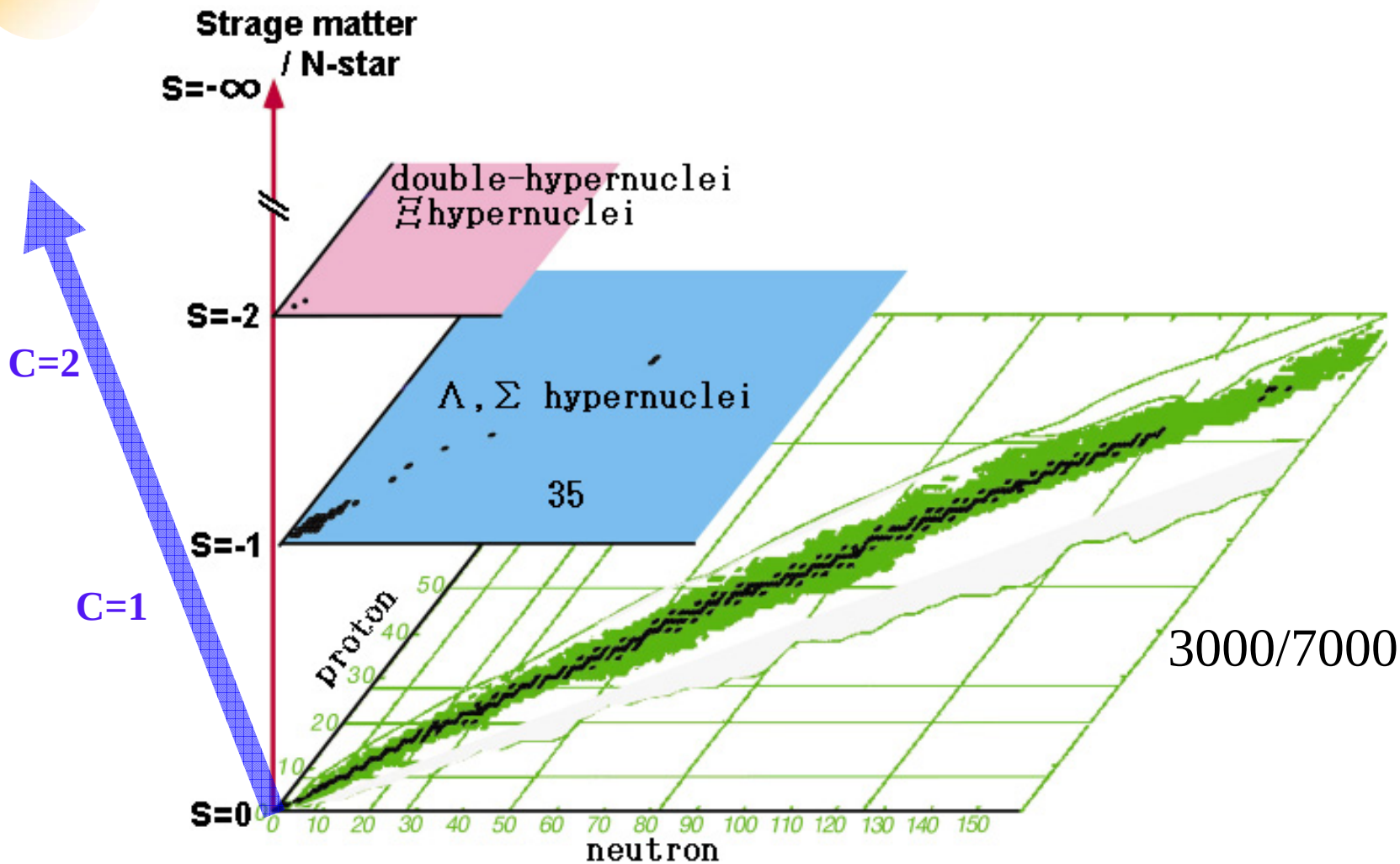


Nuclear Physics with double strangeness (S=-2)

KEK-E373 => AGS-E964 ……> J-PARC

International collaboration
AGS-E964(BNL)

Systematic Study of Double Strangeness System with an Emulsion-Counter Hybrid Method

AGS-E964 **collaborators** (now)

USA: BNL R. E. Chrien, M. May, P. Pile, A. Rusek
CMU G. B. Franklin
Houston Ed. Hungerfold, K. J. Lan, Y. Cui, Song
New Mexico B. Bassalleck
CHINA: CIAE H. Guo, Z. Liu, S. Lu, J. Zhou
INDIA: AMU R. Hasan
JPN: Gifu K. Nakazawa
Kyoto H. Funahashi, K. Imai, N. Saito, M. Yosoi
OCU K. Yamamoto, T. Yoshida
Osaka E-C H. Hotchi
Riken K. Tanida
Toho S. Ogawa, H. Shibuya
Tohoku Y. Miura, H. Tamura, M. Ukai
KOREA: GNU J. S. Song, C. S. Yoon
PUSAN J. K. Ahn, S. J. Kim
MM: MANDALAY M. Thein, K. S. Myint
UK: UCL D. H. Davis, D. Tovee
+ Graduate students

Title : Systematic Study of Double Strangeness System with an Emulsion-Counter Hybrid Method.

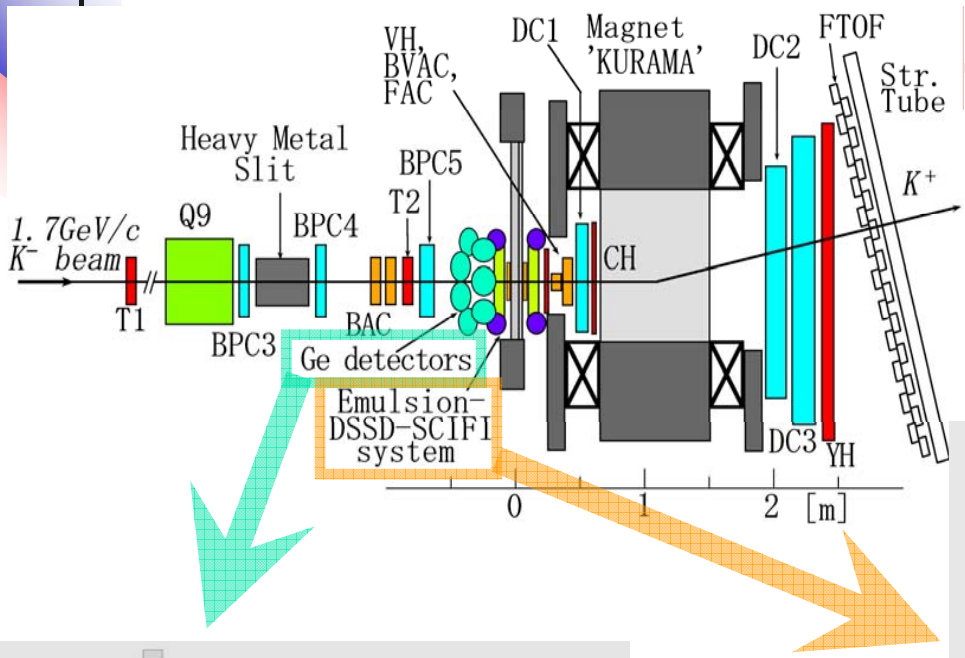
Beam : K^- (1.7GeV/c),
2×10^5 K^-/spill (4.1sec)
with **K^-/π^->9 at D6-line**

Detectors : Nuclear Emulsion,
Double-sided Si strip Detector,
Ge-Detector (Hyperball),
KURAMA magnet

Time requested :
100 hours for detector tune
100 hours for beam tune
1100 hours for beam exposure

We requested Beam time on
FY2006

Setup around the target (E964)

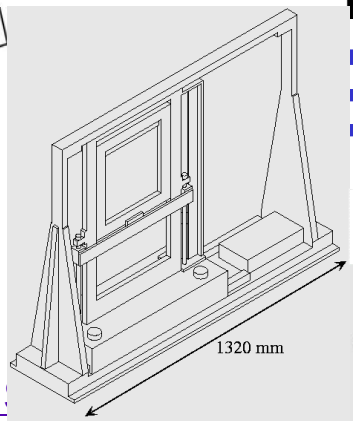


Volume of nuclear emulsion

70 *liters* (E373) => **210 *liters***

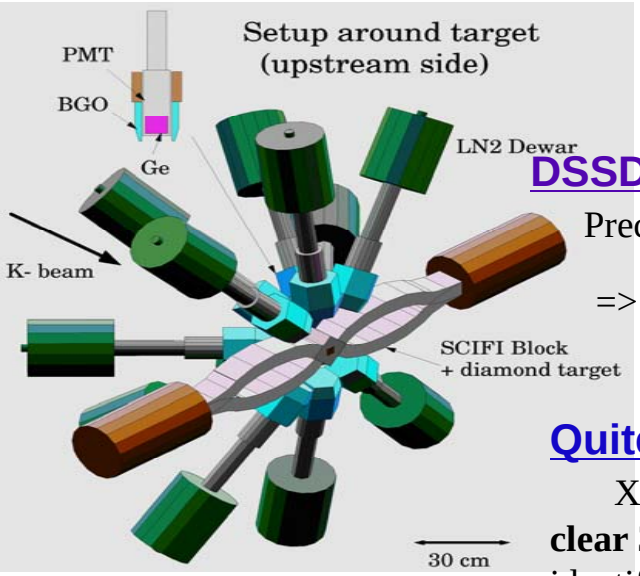
Track scanning method

Automated + Interactive (E373)
=> **Fully Automated (speed x 4)**



Emulsion Mover

- Controlled with PC
- Move emulsion during spills
- Keep track density to $1 \times 10^6/cm^2$



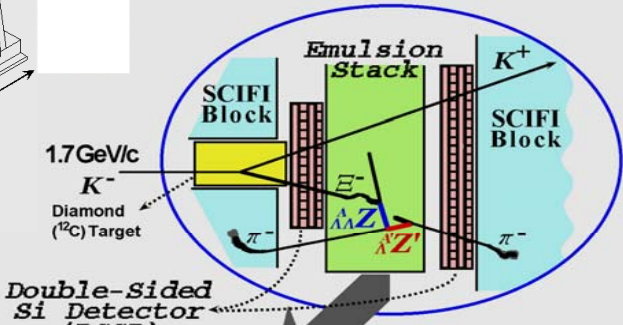
DSSD(Double-Sided

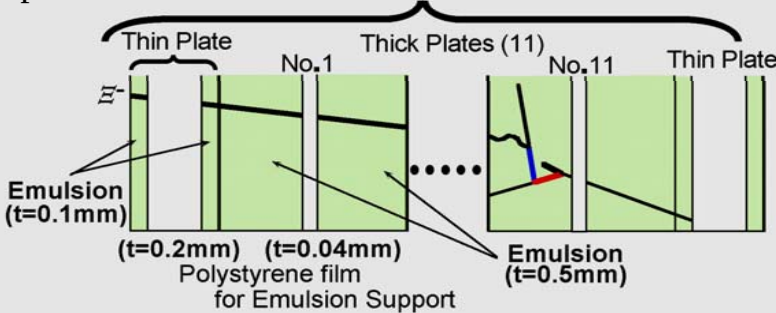
Precise prediction of Ξ^- tracks on the first emulsion plate.

=> Reduction in background tracks which are picked up in the first plate.

Quite low background

X-ray data are only analyzed for **clear Ξ^- stopping events** which are identified by nuclear emulsion.





Development of Automatic Scanning

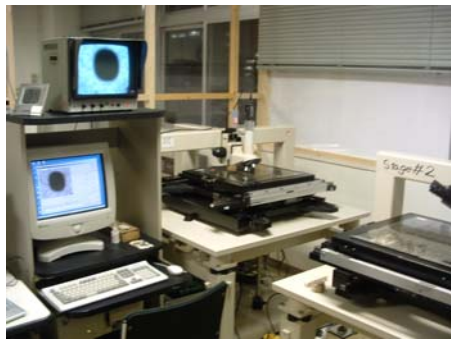
○KEK-E373

- stage drive : step-by-step
- image capture : 30Hz

⇨ **1.5~2.0** sec / one view

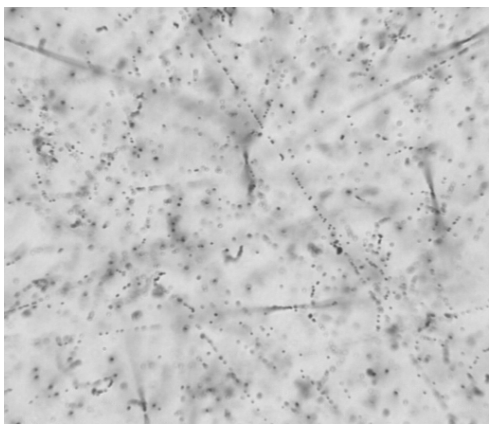
Images are shown:

1. **Surface** detection
   => **Grid** measurement
   for position calib.
2. **Track scanning**



Current system

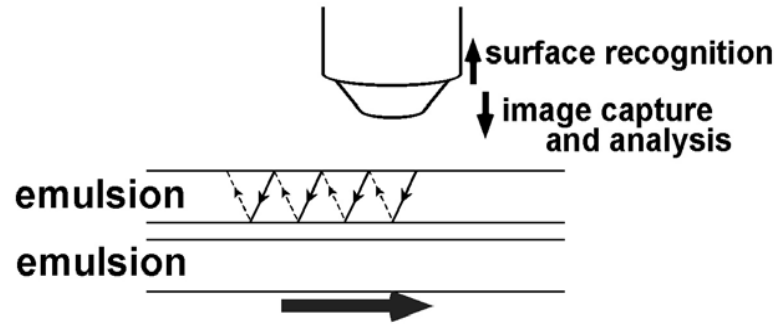
Surface & Grid : 22 sec.
Track_scan : 15 sec.



◎AGS-E964(BNL)

- stage drive : Non-Stop
- image capture : 100Hz

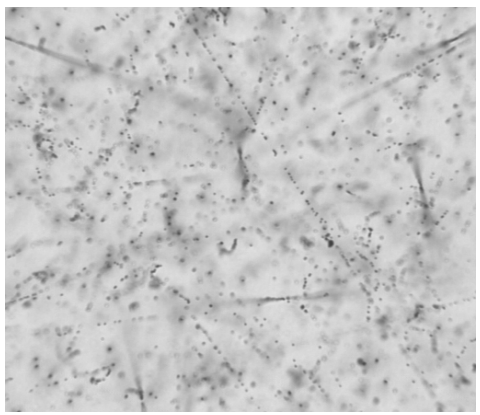
⇨ **~0.2** sec / one view
(designed value)



Non-stop driving : speed~1mm/sec

Developing system

Surface & Grid : 9 sec.
Track_Scan : 6 sec.



E964 experiment

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KEK-E373 => AGS-E964 ……> J-PARC

AGS-E964 (statistics X10 of the past experiments**)**

*) **International collaboration** (USA/China/India/JPN/Korea/Myanmar/UK)
*) **~10^4 Ξ^- stopping events** in nuclear emulsion.
*) **~10** double-Λ hypernuclei (**without any ambiguities**).
=> making **nuclear chart with S=-2**.
A-dependence of $\Delta B_{\Lambda\Lambda}$ in several nuclides.
*) **X-ray measurement** from Ξ^--atom, for the first time.
=> information of Ξ-N interaction.
*) **funded $2.5M** by JPN. Gov., already. (2003~2007)

However, the rearrangement of the beamlines are being planned for future fixed target programs and **decommissioning of D-line** is discussed.

To J-PARC (<u>50GeV proton accelerator</u> : **JHF)**

Initial PLAN : 2007 for the first beam.
PLOBLEM : **Buried cultural property was excavated.**
Goshawk (endangered species) was found.
<u>Start shall be delayed.</u>
KEK-PS shutdown (2005? for M.E. Physics).

*) **E964** leads the community of hypernuclear physics to significant activities at J-PARC.

Near Future Condition of Hadron Beams

2005(?)

2009 (?)

KEK-PS
Θ^+ experiment
with SKS [ΔE<1.5MeV]
(K.Imai)

Shutdown
for J-PARC

Desert of H.B. for
M.E. Phys?

AGS is the Unique
possible tool for M.E.
Phys. with H.B.?

J-PARC
1st Beam